SANDIA NATIONAL LABORATORIES
CIVILIAN RADIOACTIVE WASTE MANAGEMENT
TECHNICAL PROCEDURE (TP)

TP-219

COMPRESSION EXPERIMENTS AT CONSTANT STRAIN RATE

Revision 04

Effective Date: 03/05/03

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(Reviewer signatures above serve to document the review and resolution of comments.)

REVISION HISTORY

Revision	Description
0	Initial issue
1	Revised to incorporate QAIP 20-1 requirements and make other minor improvements. Procedure was generalized; earlier revision specified particular strain rate and temperature.
2	TP-219 was deactivated during Audit BSC-ARC-01-010. It is now reactivated for additional work to be performed. No major technical revisions were required from the previous revision, only references to current procedures and other minor editorial revisions.
3	The section on system checks has been eliminated from the procedure. In the past, this process was used to validate the data acquisition software. The validation of the software is now governed by a general project procedure on software and the validation process is handled in a different manner.
4	Several minor changes have been made to the process to line up with the actual test process and to add flexibility in the types of tests that can be performed. In addition, some slight modifications have been made to the Test Data Report (TDR) form to add information that is useful to the data reduction process.

1.0 Scope and Objective

This procedure applies to the performance of mechanical property experiments in compression at a constant axial strain rate. These experiments are in support of work of the Yucca Mountain Site Characterization Project.

2.0 Prerequisites

Before performing work under this technical procedure, personnel must be trained by the Principal Investigator (PI) and demonstrate their proficiency in performing the work in this procedure. The PI has the responsibility for generating a record of the personnel proficiency training, as well as the responsibility that work is performed and documented in accordance with this procedure.

The personnel using this procedure are responsible for ensuring that a controlled copy of this procedure is available and used for performing the work in this procedure.

3.0 Description of Activity

This TP will detail procedures for laboratory mechanical experiments on rock specimens. The experiments will be performed on right-circular cylinders of tuff with a nominal length to diameter ratio of 2:1. Any deviations of more than 5% to this criterion will be specified by the PI in writing and noted on the Test Data Report (TDR). The laboratory mechanical experiments will be run in compression at a constant axial strain rate under specified temperature and ambient pressure conditions.

For this experimental series, outputs from a variety of transducers (load and strain) are monitored. The output from each device is conditioned, amplified, converted to digital format, and recorded as a function of time. The outputs from the devices are recorded with a PC-based data acquisition system. The collection depends on the rate of change of the test parameters.

For the constant strain rate experiments, the loading frame is operated in displacement feedback provided by the axial extensometer mounted on the test system. The displacement can be controlled to within $\pm 10^{-3}$ mm when the system is in the displacement mode.

During each test the axial and radial displacements of the specimen are measured with appropriate electronic gages (e.g., Linear Variable Differential Transformers, or LVDTs). Either one or two gages can be used to measure the axial displacements and one or two can be used to measure the lateral displacements, depending on the test requirements.

The most direct way to measure radial strain is with a radial displacement gage similar to the one developed by Holcomb and McNamee (1984). Their gage consists of an LVDT mounted in a ring, which is spring loaded against the surface of the sample. The core of the LVDT is connected to the spring. As the sample diameter changes, the spring deflects, changing the position of the core within the barrel of the LVDT in direct proportion to the radial displacement.

The outputs of the axial and lateral gages are fed into signal conditioners where the signals are demodulated and amplified. The output signal from the conditioners is fed into an A/D converter in a microcomputer and stored in digital form.

The force on the test column is measured with an external load cell. The accuracy of the load cell is better than 2.0% of its full-scale output. The output of the load cell is amplified with a signal conditioner before it is presented to the A/D converter.

4.0 Operations

4.1 Constant Strain Rate Experiments on Rock Specimens

Specimens of tuff will be tested to failure at a constant strain rate under specified temperature (if no specification is made, then the implied condition is ambient temperature) and ambient pressure conditions. The following section includes the step-by-step procedures for the mechanical property experiments.

4.2.1 Experiment Procedures

1. The specimen designated for testing will be removed from storage. If drying and/or saturation are required, use SNL TP-65, entitled "Drying Geologic Samples to Constant Weight" and/or SNL TP-64, entitled "Procedure for Vacuum Saturation of Geologic Core Samples." All initial conditions will be documented on the TDR. A list of all transducers with their serial numbers, signal conditioning amplifier number, the computer channel on which they are recorded, and scaling factor will be recorded.

2. Visually inspect the rock core. Any major surface irregularities/imperfections should be noted on the TDR, along with a sketch and/or photograph of the specimen.

3. If required, heat the sample to the specified elevated temperature level in a furnace of sufficient size. Once at temperature, the sample will be wrapped in insulating material during transportation to the loading frame and during the conduction of the experiment, while the temperature of the sample is continually being monitored.

4. Place the sample on the base platen of the load frame.

5. Place the axial displacement gage(s) in the appropriate set-up on the rock specimen, if necessary. If the load frame LVDT is being used, then this step is not necessary.

6. Position the radial displacement gage(s) on the sample. The gage(s) is (are) positioned in such a way to ensure that the line of the displacement measurement: (1) passes through and (2) is perpendicular to the axis of the sample.

7. Connect the axial displacement gage(s) and the radial displacement gage(s) to their appropriate conditioners.

8. Make the final mechanical adjustments on the displacement gages.

9. Position the sample assembly to ensure that all the loading column components are coaxial.

10. Advance the piston on the hydraulic ram and apply an axial load of approximately 0.5 MPa on the sample. This seats the sample and all the elements in the loading column. This procedure is accomplished by manually operating the servo-controller in load feedback.

11. Change to displacement control, then using the set point control for the displacement transducer; retract the hydraulic piston until there is no force on the loading column.

12. Initiate data acquisition. The amplified outputs from all transducers are monitored and recorded using a microprocessor based data acquisition system. The conditioned output signals from the displacement gages and the force cell are presented to an A/D converter. The system consists of a computer with a data acquisition system. Data is stored only when the output of one channel deviates from the previous value by more than a pre-selected threshold.

13. Adjust the setting on the displacement rate controller to the displacement rate that corresponds to the nominal strain rate to be used in testing.

14. After a final check of all the transducer values, load the sample to failure.

15. Unload the specimen until the loading piston is out of contact with the sample.

16. Terminate data acquisition. Visually inspect data file to ensure that all the data have been collected (e.g., scroll through file or plot data). Copy the data to a disk or CD for back up.

17. If required, allow the sample to cool to ambient conditions.

18. Remove the sample from the frame and examine the manner in which the sample failed. Record the observations on the TDR.

19. Print a hard copy of the data as a permanent record of the experiment. This data set shall be attached to the TDR. Return the sample to storage.

20. Reduce the data. Commercial software with a built-in linear least square fitting function can be used. The following elastic constants will be computed:

    (a) Young's modulus, E (GPa), where E= axial stress/axial strain and

    (b) Poisson's ratio, ν, where ν = radial strain/axial strain.

The elastic constants will be computed from the data collected between approximately 25 and 50% of the failure strength. Axial stress is computed by dividing the axial force by the initial cross-sectional area of the specimen. Stress will be reported in MPa. Axial strain is obtained by dividing the axial displacement measured by the appropriate gage length. If the load frame displacement gage is used, the axial strain is calculated by subtracting the machine displacements from the total displacement and then dividing by the initial sample length. Radial strain is computed by dividing the change in displacement observed by the radial displacement gage(s) by the initial sample diameter. All strains will be reported as strain, percent strain, millistrain, ormicrostrain.

4.3 Safety

There should be no safety hazards other than the normal hazards of the equipment. Operations will be in accordance with safety requirements of the facility where the work is being performed and those of the employer of person(s) performing the work.

5.0 Nonconformance, Deviations, and Corrective Actions

Any nonconformances or deviations must be reported to the PI as soon as possible. Deviations, deficiencies and corrective actions must be determined and documented in accordance with AP-15.2Q, *Control of Nonconformances* and AP-16.1Q, *Management of Conditions Adverse to Quality*.

6.0 QA Records

QA records, and any corrections or changes thereto, generated as a result of implementing this procedure will be prepared and submitted as inclusionary QA records (QA:QA) by the PI in accordance with AP-17.1Q, *Record Source Responsibility for Inclusionary Records*. These records include:

- Proficiency training records (Section 2.0)
- Test Data Reports (TDR) (Section 3.0)
- Calibration records (if applicable)

7.0 References

Holcomb, D. J. and M. J. McNamee, 1984. *Displacement Gage for the Rock Mechanics Laboratory*. SAND 84-0651. Albuquerque, New Mexico: Sandia National Laboratories.

TP-64, *Vacuum Saturation of Geologic Core to Constant Weight*

TP-65, *Drying Geological Samples to Constant Weight*

AP-15.2Q, *Control of Nonconformances*

AP-16.1Q, *Management of Conditions Adverse to Quality*

AP-17.1Q, *Records Source Responsibility for Inclusionary Records*

TEST DATA REPORT (**TDR**) Page ____ of ____

Sample Preparation Details

Test/Sample ID: _____ Requester/PI: _____

Technician(s): _____

Date(s) of preparation: _____

Sample Material (rock type, unit, etc): _____

_____

_____

Diameter: _____ Length: _____ L:D ratio: _____

Sample Area: _____ Weight: _____ Other: _____

Sketch of Sample:

Preparation Details: _____

_____

_____

_____

Instrumentation Type & Serial Number	Gage Length, etc.	Gage Location

Prepared By: Name: _____ Sign/Date: _____

*** Attach continuation pages as needed. ***

TEST DATA REPORT (TDR) Page ____ of ____

Data Recording Information

Test/Sample ID: _____ Requester/PI: _____

Machine Used: _____ Controller Type: _____

Required Test Conditions (e.g., rate, temperature): _____

_____

Controller Settings: Function Generator Settings:

Variable:	Range, Full Scale:	Span %:	Rate:	Time:
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Attach printout of setup, if desired.

Variables Recorded:	Scale Factors:	Shunt Calibration (V):
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Data Storage File Names:	Contents:
_____.SET	Setup File
_____.DAT	Data File
_____.HDR	Header File
_____.PRN	Setup Summary File
_____	_____

Comments (Use continuation page, if necessary):

_____

_____

_____

Prepared By: Name: _____ Sign/Date: _____

*** Attach continuation pages as needed. ***

TEST DATA REPORT (**TDR**) Page ____ of ____

Continuation Page

Test/Sample ID: _____ Requester/PI: _____

Prepared By: Name: _____ Sign/Date: _____